

Role of forensic odontology and anthropology in the identification of human remains

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Abstract

Forensic odontology and anthropology play an important role in the identification of humans/victims in mass disasters (accidents and earthquakes) and criminal cases (homicide, rape and suicide) even if less available human remains or samples. Forensic also helps in the identification of age, sex, stature estimation and race identification using photographs, bite marks, lip prints, palatal rugae, radiographs and dental DNA identification if antemortem records are available. Here, we review the available methods of human identification. Cone-beam computed tomography of the skull showed superiority in comparison of both facial skeletal and soft tissue to examine the teeth, occlusion, palatal rugae, soft tissue thickness and other unique features.

Keywords: Anthropology, cone-beam computed tomography, forensic, human remains, identification

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INTRODUCTION

Human race has different identities and variations of their own. Identification of an individual using unique dental features and cranial evidences other than conventional methods such as fingerprints is increasing due to advancements in technology and less availability of human remains. The word forensic is derived from the Latin word "forensis," which means "before the forum," which simply means "public discussions."^[1] The two modern usages of the word "forensic" are as a form of legal evidence and as a category of public presentation. Forensic odontologists and anthropologists play a major role in the identification of human deceased. It also provides various details such as age, sex, stature and race identification. Here, we review the role of forensic odontology and anthropology in

the identification of human remains from the existing literature.

FORENSIC ODONTOLOGY

History of forensic odontology dates back from the ancient Roman Empire to our present modern 21st century and still developing. Dr. Oscar Amoedo universally recognized as the father of forensic odontology because of his work in the identification of victims of fire accidents in Paris, France, in 1898. Federation Dentaire Internationale defined forensic odontology as that branch of dentistry that, in the interest of justice, deals with the proper handling and examination of dental evidence, and with the proper evaluation and presentation of dental findings.^[2] Forensic

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odontologist and a dentist is actively involved in various purposes of forensic odontology in situations such as mass disaster, civil and criminal investigations, child abuse and various other activities, where they use dental features including anatomy, number and position of the teeth, palate, prosthetic restoration, bite marks and lip prints as a key for their investigations. Mouth extremely gives a great number of details for information for identification of victim in the field of forensic dentistry.

Based on the major fields of activity, Avon classified forensic odontology into civil, criminal and research.^[3] The civil field is concerned with mass disasters such as airline accidents, earthquakes or train accidents which require identification of the victims in advanced stages of physical destruction. It is also concerned with malpractice and different types of fraud and neglect where damage may be sought. It also deals with the age assessment of individuals in absence of birth certificate. The criminal field is concerned with the identification of persons from their dental remains alone in cases of homicide, rape or suicide through bite mark analysis, palatal rugoscopy and cheiloscropy. Finally, the research field is devoted to forensic odontology training for medical and dental professionals.

Three important activities of forensic odontologists are examination and evaluation of injuries of teeth, jaws and orofacial structures, examinations of the bite marks and examination of dental remains, which happened due to various fields of activities as mentioned above. Role of dentists in this field includes a comparison of dental features of victim's sample in civil and criminal fields which include rape, suicide, mass disaster, reconstructive postmortem and many others using bite marks, lip prints, amelogyphics and radiographic evidence with the previous records such as photographs, casts models and dental X-rays.

ANTHROPOLOGY

Anthropology, "the science of humanity," studies human beings in aspects ranging from the biology and evolutionary history of *Homo sapiens* to the features of society and culture that decisively distinguish humans from other animal species. This study of human being has multiple specialties such as social, cultural, psychological, linguistic, physical and archaeology. Role of the anthropologist in the field of forensic has an important role in using skeletal remains through craniofacial superimposition, facial approximation, unique cranial evidence, frontal sinus variations and postcranial remains.^[4]

IDENTIFICATION OF HUMAN REMAINS

Forensic odontologists and anthropologists have been into many fields such as identifying unknown human remains through dental records and assisting at the scene of a mass disaster, assuming/building up a picture of lifestyle and diet of skeletal remains at archaeological sites, identify age, sex, stature estimation and race of both living and deceased. We can also use photographs, bite marks, lip prints, palatal rugae, radiographs, amelogyphics and skeletal remains for identification of the above mention details. Forensic odontology involves all dental specialties and is hence also known as "Forensic dentistry." Maintenance of legible dental records such as clinical photographs, patient details, digital dental impressions, cast models, radiographs, pathological reports and many will assist legal authorities in identification of victims and suspects. The forensic odontologist should have broad background knowledge of general dentistry, encompassing all dental specialties and he should have basic knowledge of the role of forensic pathologist and the methods used in autopsy. Similarities and discrepancies should be noted during the comparison of antemortem and postmortem reports.

There are two types of discrepancy,^[5] those that can be explainable and those that cannot.

1. Explainable discrepancies: Normally related to the time passed away between the antemortem and postmortem records. Examples include teeth extracted or restorations placed or enlarged
2. Unexplainable discrepancies: For example, if a tooth is not present on the antemortem record but is present on the postmortem record, then an exclusion should be made. A range of conclusions can be reached when reporting a dental identification.

Estimation of age, sex, race and stature will create four pillars of the anthropological protocol and may be essential in preliminary screening and reconstructive identification of skeletal remains [Table 1].^[6]

Age estimation

Estimations of age at death and determination of sex of the victim or remains are important guides that help in the process of identification. Age of a person can be given in various forms such as chronological age, anatomical age, dental age, sexual age and mental age. Medicolegal and anthropological importance of age estimation includes criminal cases, judicial punishments, marriage, employment, kidnapping, rape and many.^[1]

Table 1: The American Board of Forensic Odontology recommends that these be limited to the following four conclusions

Conclusions	Inference
Positive identification	Antemortem and postmortem data match in sufficient details, with no unexplainable discrepancies, to establish that they are from the same individual
Positive identification	Antemortem and postmortem data have consistent features but, because of the quality of either the postmortem remains or the antemortem evidence, it is not possible to establish identity positively
Insufficient evidence	The available information is insufficient to form the basis for a conclusion
Exclusion	The antemortem and postmortem data are clearly inconsistent

Harvey lists the following factors as those which may aid in the dental age estimation.^[7] They are:

- Appearance of tooth germs
- Earliest detectable trace of mineralization
- Degree of completion of the unerupted tooth
- Rate of formation of enamel and formation of the neonatal line
- Clinical eruption
- Degree of completion of roots of erupted teeth
- Degree of resorption of deciduous teeth
- Attrition of the crown
- Formation of physiologic secondary dentin
- Formation of cementum
- Transparency of root dentine
- Gingival recession
- Root surface resorption
- Discoloration and staining of teeth
- Changes in the chemical composition of the teeth
- Influence of disease or malnutrition on tooth eruption
- Influence of sex on tooth eruption.

According to the technique of investigation age can be identified through:

- Clinical or visual
- Radiographic
- Histological
- Physical and chemical analysis.

SEX DETERMINATION

In addition to the determination of age, sex can also be determined from the teeth. Determination of sex using skeletal remains presents a great problem to forensic experts, especially when only fragments of the body are recovered. Forensic dentists can assist other experts to determine sex of the remains using teeth and skulls. Various features of teeth, such as morphology, crown size and root lengths are characteristic for male and female sexes. There are, also, differences in the skull patterns. These will help a forensic

odontologist to identify the sex. New developments such as polymerase chain reaction (PCR) amplification will assist in accurately determining the sex of the remains.^[8,9]

STATURE ESTIMATION

Stature is shown to have a definite and proportional relationship with many parts of the human body such as the cranial and facial bones, long bones, trunk and foot bones. Stature estimation from the dentition, however, has seldom been explored. Prabhu *et al.* correlated the stature using measurement of fulness of the tooth crown, which showed that the dentition may be used only as a supplement to more robust indicators of stature.^[10]

RACE/POPULATION IDENTIFICATION

Physically, humans are a diverse species. This diversity is the result of genetic influences as well as environmental factors such as climate and geographic location. Therefore, the people of the world look different. Conventionally, the human species has been categorized into three “races” – Caucasoid, Mongoloid and Negroid. This classification, however, does not reflect the human variation. Moreover, Relethford has emphasized that the concept of “race” is rather ambiguous [Table 2].^[11]

PHOTOGRAPHS

Photographs are essential and valuable replacement for written and audio evidence. Not all photographs are necessary for documentation. Advancement in technologies made the photographs an essential evidence and also leads to doubtful forgeries, which made to have considerable limitations and technique sensitive procedures for accurate reproduction. Due to two-dimensional (2D) projections of 3D objects with color change, poor quality and technique made the photography an unreliable evidence. However, 3D photography, improvement in quality of image (Megapixels), lighting, techniques, digital impressions and many led photography to get accept readily in the field of forensic dentistry. Photography along with written records will add up the accuracy and reproducibility of details. “Cromwell Street murders” or the “Frederick and Rosemary West” case is the best example to show the use of photograph as a valuable tool for the dentist in human identification.^[12,13]

BITE MARK ANALYSIS

Bite marks are nothing but injury or indentations caused by teeth either alone or in combination with other parts of the mouth on skin or objects. Bite marks are always associated with assaults, sex crimes and child abuse which

have distinctive patterns and can also be found from the place of theft. Drawbacks of bite mark analysis include short duration, incomplete bites and less reliability with less number of teeth. Its appearance can be identified based on the type of injury, duration of incident/crime scene, site, individual characteristics of tooth, color, size and shape through photographs (2D and 3D), impressions and digital impressions. This bite mark analysis and comparison is a challenging job for the forensic department because of multiple combinations due to flexibility of tissue, jaw movements, distortion of impression or faulty photographs and many.^[14]

There are seven types of bite marks:^[15]

1. Haemorrhage (a small bleeding spot)
2. Abrasion (undamaging mark on skin)
3. Contusion (ruptured blood vessels, bruise)
4. Laceration (near puncture of skin)
5. Incision (neat punctured or torn skin)
6. Avulsion (removal of skin)
7. Artefact (bitten-off piece of body).

Following comparison, a bite mark analysis may have one of the following concluding statements as suggested by Levine and the ABFO [Table 3].^[11]

Table 2: Methods of human identification

Photographs
Bite mark analysis
Cheiloscopy
Rugoscopy
Radiographs and scans
Role of DNA in dental identifications

Table 3: A bite mark analysis may have one of the following concluding statements as suggested by Levine and the American Board of Forensic Odontology^[11]

Conclusions	Inference
Definitive biter	There is concordance of sufficient distinctive, individual characteristics to confer uniqueness within the population under consideration. There is absence of any unexplainable discrepancies
Possible biter	Bite mark shows some degree of specificity to the suspect's teeth by virtue of a sufficient number of matching points, including some corresponding individual characteristics. There is absence of any unexplainable discrepancies
Possible biter	The bite mark and the suspect's dentition are consistent: Although the suspect's teeth could have made the bite mark, there are no characteristic matches to be absolutely certain. The similarity is nonspecific or there is similarity of class characteristics. Matching points are general and/or few and there are no incompatible inconsistencies that would serve to exclude the bite mark as having been caused by the suspect
Not a biter	The bite mark and the suspect's dentition are not consistent: Features on the bite mark indicate that the suspect's teeth have definitely not caused them

CHEILOSCOPY

Human lip has numerous lines and furrows in the form of wrinkles and grooves located between labial mucosa and outer skin. Impression of these wrinkles and grooves with moisture over any object will lead to form lip prints. It is obtained at the crime scene from glasses, cups, cigarettes, windows, doors and clothes. The study of lip prints is also known as cheiloscopy. These lip prints are genetic, once developed at the sixth month of intrauterine life. It is unique, permanent and unchangeable even after death.^[16]

Tsuchihashi *et al.*'s classification of lip prints,^[17]

- Type I – Clear-cut vertical grooves that run across the entire lip
- Type I – Similar to Type I but do not cover the entire lip
- Type II – Branched grooves
- Type III – Intersected grooves
- Type IV – Reticular grooves
- Type V – Grooves that cannot be morphologically differentiated.

RUGOSCOPY

Palatal rugae are ridges located on the anterior part of the palate extending bilaterally from the mid-palatine raphae behind the incisive papilla. It is useful in both dentulous and edentulous subjects and is unique for every individual. These rugae are well protected by lips, cheek, alveolus, teeth and tongue during high impact trauma, assaults, mass disaster and fire accidents. Rugae is compared with the previous photographs, dental cast, digital impression and cone-beam computed tomography (CBCT) from the dental records using software programs.^[18]

Rugae are divided into three categories^[11] which are measured from mid palatine raphae to terminals laterally. They are:

- Primary rugae (>5 mm)
- Secondary rugae (3–5 mm)
- Fragmentary rugae (2 < 3 mm).

Rugae <2 mm are not take into considerations.

RADIOGRAPHS AND SCANS

Radiographs are a great tool in the identification of human remains if sufficient antemortem records are present. Odontological and osteological comparison of antemortem and postmortem records by forensic odontologist and anthropologist along with dentists through intraoral radiographs, extraoral radiographs such

as orthopantomogram, various views of skull, CT scan and CBCT scan plays a major role. Unique dental and skeletal features of an individual like number of teeth, anomalies, restorations, prosthesis, pathologies, craniofacial superimposition, unique cranial evidence, frontal sinus variations and post cranial remains can be noted in these advanced radiographic tools, which will help in easy identification of victims/subjects.^[11,19]

CBCT, a variant of CT of head-and-neck and dentomaxillofacial regions, has an outstanding role in the field of forensic dentistry. This noninvasive CBCT also helps in determination of soft tissue structures of orofacial region with low dose (139 µSV) but comparatively high exposure than that of periapical and panoramic images. Hwang *et al.*'s study on soft tissue thickness of the Korean population using CBCT showed to have an effective role in forensic craniofacial reconstruction procedures using standard landmarks of facial hard and soft tissues. This CBCT will help the forensic department in all aspects such as age estimation, sex determination, stature exposure, race identification, bite mark analysis, cheiloscopy and many.^[20-23]

ROLE OF DNA IN DENTAL IDENTIFICATION

Dental records of other conventional methods of identifications of all subjects are not completely available. Teeth are an excellent source of DNA. Teeth provide sufficient quantities of DNA for analysis even after years of postmortem. Routine forensic investigations such as PCR allow amplification of even highly degraded DNA. DNA of tooth is compared with the biological antemortem samples of the decedent, such as hair from a comb, epithelial cells from a toothbrush or biopsy specimen. It can also be compared with the DNA of parents or siblings.^[11,24]

CONCLUSION

Advancement in technologies improves or makes the work of forensic odontologist, anthropologist and dentist in a simpler form than that of conventional methods. CBCT plays a major role in forensic dentistry in all aspects osteological, odontological and soft tissue comparison of antemortem with that of postmortem records. All these methods of identification of human remains are possible only if antemortem records are available which should be done only by the dentists, radiologists and maxillofacial surgeons except dental DNA method of identification.

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Conflicts of interest

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